"Method for manufacturing a composite trim part for the interior of an automotive vehicle."

The invention relates to a method for manufacturing a composite trim part which is arranged to be mounted in particular in an automotive vehicle to form a part of the interior thereof and which comprises a laminate of a flexible skin layer, a rigid backing substrate layer and an intermediate layer, usually a foam layer, arranged between the flexible skin layer and the rigid substrate layer and adhering the flexible skin layer and the rigid substrate layer to one another. The invention relates in particular to a so-called backfoaming process.

In a first aspect of the invention, the method comprises the steps of:

- providing a mould comprising a first mould half, having a first mould surface with a predetermined three-dimensional shape, and a second mould half, having a second mould surface with a further predetermined three-dimensional shape, the first and second mould halves being movable with respect to one another to open and close said mould and defining a first mould cavity in the closed mould position;
- forming the flexible skin layer with its front or visible side against the first mould surface according to a low pressure forming process ;
- forming said rigid substrate layer with its back side against the second mould surface;
- bringing both mould halves together to close the mould, with a gap remaining between the skin layer on the first mould surface and the substrate layer on the second mould surface;

– applying, either before and/or after having closed the mould, a curable material between the skin layer on the first mould surface and the substrate layer on the second mould surface, and allowing it to cure in the closed position of the mould to produce the intermediate layer in said gap, the curable material being in particular a foamable material which is allowed to foam in the closed position of the mould ; and
– opening the mould and removing the moulded trim part therefrom.

Backfoaming processes are already used to produce trim parts for automobiles. In the patent publications a so-called direct backfoaming process is for example disclosed in WO 02/26461. In this known direct backfoaming process, a liquid polyurethane reaction mixture is sprayed against the surface of a first mould half whilst a pre-manufactured rigid substrate layer is positioned onto the second mould half. The mould is then closed and a foamable polyurethane reaction mixture for producing a foam layer is injected in the mould cavity, more particularly in the gap between the skin layer and the rigid substrate layer. Instead of injecting this reaction mixture in this mould cavity, it is also possible to pour the foamable reaction mixture onto the skin layer on the first mould half and to close the mould before the formation of the foam layer is completed, i.e. so that the foamable reaction mixture still foams after having closed the mould.

A first drawback of this known method is that the rigid substrate layer has to be manufactured in advance, in separate moulds and usually by another manufacturer. The rigid substrate layer is usually made of a thermoplastic material by injection processes requiring specific tools which are not used in the common backfoaming processes. Production of the rigid substrate layers by other manufacturers may cause all kind of problems such as fine-tuning mistakes, dimensional deviations due to the CAD exchange between the manufacturers, variations in the shape and dimensions of the substrate layers due to

temperature and humidity influences during the required storage and transport, material shrinkage tolerances, and logistic problems. Separate manufacturing of the rigid substrate layers involves more process steps and therefore also increases the costs of the automotive interior trim parts.

A further drawback of this known direct backfoaming method is that the pre-manufactured substrate layer has to be positioned accurately onto the second mould surface. Such a positioning requires sophisticated tool elements. The process is moreover quite time consuming whilst the positioning of the substrate layer on the second mould surface is still not optimal. The dimensions of the rigid substrate layer may vary for example within particular tolerances. This makes it difficult to assure that the rigid substrate layer fits each time perfectly against the second mould surface. Even the dimensional variations caused by environmental fluctuations (temperature, humidity) during storage may cause such problems. An imperfect positioning of the rigid substrate layer has first of all an effect on the thickness of the relatively thin foam layer produced between the rigid substrate layer and the skin layer. This foam layer provides for a so-called soft touch so that a difference in foam thickness may have an effect on the touch of the trim part. Moreover, imperfect positioning of the rigid substrate layer on the second mould surface will lead to unaesthetic transitions between different trim parts, when these are mounted, in particular clipsed, next to one another by means of attaching means on said substrate layer. Separate manufacturing of the rigid substrate layers therefore does not only increase the costs of the automotive interior trim parts but has also an adverse effect on the quality of the automotive interior trim.

In another known direct backfoaming process, which is disclosed in US 2003/0042643, a number of the above-described drawbacks have been obviated. In this know direct backfoaming process,

the skin layer is produced by a spray or a vacuum forming process against the first mould surface whilst the rigid substrate layer is produced by an injection moulding process against the second mould surface. The rigid substrate layer is more particularly produced by injecting a molten thermoplastic material under a high pressure in a mould cavity formed by the second mould half and by a further first mould half.

In the method disclosed in US 2003/0042643 the rigid substrate layer is no longer manufactured separately. Moreover, there is no longer the technical problem of accurately positioning the substrate layer in the backfoaming mould and furthermore, only three mould halves are required instead of four mould halves. Although the method and device in US 2003/0042643 solve a lot of technical problems of the direct backfoaming processes as known in the prior art, this method apparently has not yet been used in practice, which is due to important drawbacks of the described method. First of all, the injection mould for producing the rigid substrate layer needs to be very robust and is therefore quite expensive. Moreover, the production capacity of the injection mould cannot be optimally used unless, as described in the US patent application, several backfoaming moulds are used in combination with one injection mould. It is clear that in this way the complete installation will be very complex and expensive. Although high production rates are possible with such an installation, the backfoaming moulds all have to be identical so that this high productive capacity can only be used for producing one type of trim part at the same time. Consequently, if the injection moulding installation is to be used in an optimal way, several backfoaming moulds have to be provided for each of the different trim parts. Moreover, since the second mould halves of the backfoaming moulds are also used as mould halves of the injection mould, they all have to be made much more robust than the conventional backfoaming mould halves. Consequently, the advantages which can be achieved by

the method disclosed in US 2003/0042643 are outweighed by the high investment costs.

An object of a first aspect of the present invention is therefore to provide a new backfoaming method wherein separate manufacturing of the rigid substrate layer and storage of the substrate layers is avoided and wherein further no separate positioning step is required to position the rigid substrate layer accurately onto the second mould surface whilst even enabling a more accurate and reliable positioning of the rigid substrate layer with respect to the flexible skin layer without requiring however such a high capital outlay as the method disclosed in US 2003/0042643.

To this end, the method according to the invention is characterised in the first aspect of the invention in that, not only the skin layer but also the substrate layer is formed according to a low pressure forming process, the low pressure forming process for forming the skin layer and the low pressure forming process for forming the substrate layer being selected, independently from one another, from the group consisting of a spray process, a reaction injection moulding process, a liquid or powder slush moulding process and a thermoforming process.

In this first aspect of the invention, the rigid substrate layer is formed against the second mould half surface of the backfoaming mould so that it is automatically accurately positioned with respect to the flexible skin layer which is formed against the first mould half surface of the backfoaming mould. Moreover, no separate manufacturer is required to supply the different substrate layers for the various types of automotive trim parts. The rigid substrate layers also do not have to be stored so that dimensional variations as a result of temperature and humidity fluctuations are avoided. For each type of flexible skin or trim part, the appropriate rigid substrate layer is each time readily available since it is formed at the same time as the flexible skin layer. The installation costs

can further be reduced since the second mould half of the backfoaming mould is no longer only used for the backfoaming process but also for the production of the rigid substrate layer. Due to the fact that the rigid substrate layer is produced in accordance with a low pressure forming process, the second mould halves of the backfoaming moulds do not have to be made more robust. Moreover, the installations for low pressure forming processes, in particular for spray, RIM, slush and thermoforming processes, are considerably less expensive than injection moulding installations. In contrast to the method disclosed in US 2003/0042643 all of the above described advantages enable to produce automotive trim parts at a lower cost and/or with a higher quality.

GB-A-1 263 620 discloses a method for producing trim parts for automobiles wherein a skin layer is formed on one surface of a backfoaming mould and wherein a reinforcing and attaching element is produced on a lid. Before closing the mould by means of this lid, a foamable material is added into the cavity formed by the skin in the mould so that the skin layer is adhered to the reinforcing and attaching element on the lid. This reinforcing and attaching element is made by pouring a liquid plastics material in a removable frame on the lid. An important difference with the method according to the first aspect of the invention is that this known method does not enable to manufacture trim parts which comprise a three-dimensionally shaped laminate of a skin layer, a backing substrate and an intermediate foam layer. Indeed, in order to enable to pour the reinforcing and attaching element, the lid of the mould has to be flat, i.e. it may not be shaped three-dimensionally. Consequently, the reinforcing and attaching element cannot follow the three-dimensional contour of the skin layer so that no laminate can be achieved wherein the rigid substrate layer has a three-dimensional shape which corresponds generally to the three-dimensional shape of the skin layer.

In the direct backfoaming processes which are used nowadays, the first and second mould halves are continuously connected to one another during the production process and are thus moved simultaneously through the different workstations. Such a process presents a number of drawbacks. First of all the total weight of the first and second mould halves, and of the mould carriers onto which these mould halves are mounted so that the moulds can be opened and closed, is so high that a robust installation or transfer line (f.e. power of transport motors, weight load of supporting frames, ...) is required to transport the moulds between the workstations. Moreover, notwithstanding the high weight, the moulds have to be positioned quite accurately in some of the workstations, for example in the workstation wherein the skin layer is sprayed by means of a spray robot. This requires rather complex positioning devices. Another drawback is that the entire installation is further also expensive in view of the fact that a relatively large number of complete moulds are needed to enable a continuous production. In practice, fifteen to twenty five moulds are for example used to complete a direct backfoaming process, the moulds being for example of five to seven different versions.

An object of a second aspect of the present invention is therefore to provide a new direct backfoaming method which enables to reduce the costs of the moulds and the installation in a continuous line for manufacturing interior trim parts.

To this end, the method according to the invention is characterised in the second aspect of the invention in that, for carrying out the different direct backfoaming steps, the first mould half is passed through a first circuit of successive workstations and the second mould half through a second circuit of successive workstations, the first and the second circuit comprising a chain of successive workstations which are common to the first and the second circuit and which comprise a first

workstation, wherein the first and second mould halves are joined to one another, and a last workstation, which is situated downstream the first workstation and wherein the first and second mould halves are released from one another, the first circuit comprising further a first chain of successive workstations, through which the first mould half is passed separated from the second mould half, the foam layer being produced in said common chain of workstations whilst the flexible skin layer is produced in said first chain of workstations, the rigid substrate layer being either applied on the second mould surface in said common chain of workstations or the second circuit of successive workstations comprises, in addition to said common chain of workstations, at least one workstation wherein the rigid substrate layer is applied on the second mould surface.

Since it takes at least for the first mould halves a relatively long time before they have passed the line for producing the flexible skin layer, and since the first mould halves can now be passed through this line without the second mould halves, the installation can be made less robust and it is easier to position the first mould halves accurately in the different workstations. Moreover, especially when use is made of pre-manufactured rigid substrate layers or when these substrate layers are thermoformed on the second mould surfaces, it takes much less time to apply the rigid substrate layers onto the second mould halves so that a much lower number of second mould halves is needed. This results in a considerable mould cost reduction, especially when pre-manufactured substrate layers are used since, in this case, only one workstation is required to position the pre-manufactured substrate layers.

In the direct backfoaming processes which are used nowadays, the first mould cavity of the backfoaming mould is sealed by means of an inflatable seal arranged behind the rigid substrate layer in a groove in the second mould half and by means of an upstanding cutting

edge, opposite the inflatable seal, on the surface of the first mould half. In case of substrate layers which are somewhat compressible (for example is case of a mixture of natural fibres and polyurethane resin) and which do not show too much contour variations, the known sealing concept is effectively working. The substrate layer is compressed on the upstanding cutting edge and the mould is sealed hereby against foam and gas leakage. This sealing concept is however not working for non-compressible substrate layers such as PP or ABS, for substrate layers with considerable contour variations (complex moulds) and for substrate layers with considerable production tolerances. When producing the rigid substrate layer by applying a flowable and/or molten substrate material onto the second mould surface, the known sealing concept can even not be used since it is not possible to apply an inflatable seal in the second mould surface onto which the flowable and/or molten material for the rigid substrate layer has to be applied.

An object of a third aspect of the present invention is therefore to provide a backfoaming method wherein a new sealing concept is used which enables to achieve an effective seal, even for substantially non-compressible substrate layers, and which does not require the presence of an inflatable seal in the second mould surface.

To this end, the method according to the invention is characterised in the third aspect of the invention in that, upon closing the backfoaming mould, the flexible skin layer and the substrate layer are pressed onto one another over a contact zone having a width smaller than 10 mm, preferably smaller than 5 mm, and more preferably smaller than 3 mm, the flexible skin layer having in said contact zone a thickness of at least 0.3 mm, and preferably of at least 0.4 mm, and the contact zone having preferably a width larger than 1 mm, more preferably larger than or equal to 2 mm.

In practice, the production tolerances of the mould halves are usually smaller than 0.1 mm. It has now been found that, when providing a zone of contact between the rigid substrate layer and the flexible skin layer which has a width smaller than 10 mm and wherein the skin layer has a thickness of at least 0.3 mm, the tolerances of the mould halves can be compensated for by a compression of the flexible skin layer. When spraying the skin layer, an upstanding edge is preferably provided on the surface of the first mould half, which upstanding edge has a top surface shaped to enable to spray a layer of the reaction mixture for the skin layer of at least 0.3 mm on this top surface. In contrast to the known cutting edges, the top surface of the upstanding edge is preferably substantially flat and has a width of at least 1 mm, preferably of at least 2 mm or the top surface is convex and shows an overall curvature radius larger than or equal to 2 mm. The top surface may be smooth or may show a surface relief. It may in particular be undulated or ridged.

The sealing concept of the third aspect of the invention cannot only be applied in direct backfoaming processes but also in conventional backfoaming processes wherein a pre-manufactured skin is applied onto the first mould surface or wherein a thermoplastic foil (such as a PVC, TPU or TPO foil) is applied and thermoformed against the first mould surface to form the flexible skin layer. In the zone of contact between the rigid substrate layer and the flexible skin layer, the first mould surface is preferably heated to weaken the flexible skin layer.

Other particularities and advantages of the invention will become apparent from the following description of some particular embodiments of the method according to the present invention. This description is only given by way of example and is not intended to limit the scope of the invention as defined by the appended claims. The

reference numerals used in this description relate to the annexed drawings wherein:

Figure 1a to 1f illustrate schematically the different steps of a first embodiment of the method according to the invention wherein a flexible skin layer is sprayed on a first mould half and a rigid substrate layer on a second mould surface, wherein a foamable material is poured onto the flexible skin layer before closing the mould and wherein the mould is opened and the trim part demoulded;

Figure 2 is a variant of Figure 1a illustrating the production of the flexible skin layer by means of a RIM instead of a spray process;

Figure 3 is a variant of Figure 1b illustrating the production of the rigid substrate layer by means of a RIM instead of a spray process;

Figure 4 shows on a larger scale a detail of Figure 1d illustrating the sealing concept between the sprayed skin layer and the sprayed substrate layer;

Figures 5 to 7 are the same views as Figure 4 illustrating different embodiments of the sealing concept according to the invention;

Figure 8 is a diagram of a possible transfer line for producing automotive interior trim parts wherein both the flexible skin layer and the rigid substrate layer are produced by means of a spray process;

Figure 9 is a diagram of a possible transfer line for producing automotive interior trim parts wherein the flexible skin layer is produced by means of a spray process and wherein use is made of pre-manufactured rigid substrate layers;

Figure 10 shows a schematic front view on a door panel containing local glass fibre mats as reinforcement;

Figure 11 shows a same view as Figure 10 but illustrating a door panel containing metal wires as reinforcement;

Figures 12 to 16 show cross-sectional views of different shapes of possible trim parts; and

Figures 17 and 18 illustrate the cavity formed by the concave mould surface.

The invention generally relates to a method for manufacturing composite trim parts which, as illustrated for example in Figure 1f, comprise a flexible skin layer 1, a rigid backing substrate layer 2 or carrier and an intermediate layer 3 adhering the flexible skin layer to the rigid substrate layer. Such trim parts are usually self-supporting or shape-sustaining and are especially used as automobile interior parts such as dashboards or instrument panels, door panels, consoles, glove compartments, headliners, covers, etc. The different layers form a laminate which is normally three-dimensionally shaped. In such a laminate, the substrate layer has a three-dimensional shape which corresponds generally to the three-dimensional shape of the skin layer.

The skin layer 1 has usually a front side showing a certain texture, such as a leather texture. It may consist of a thermoplastic material such as PVC, TPU, or a TPO. Preference is given however to an elastomeric non-cellular or micro-cellular polyurethane skin layer made of a liquid polyurethane reaction mixture. The average density of the polyurethane skin layer is preferably higher than 200 kg/m^3, more preferably higher than 400 kg/m^3 and most preferably higher than 700 kg/m^3. The front surface of the trim part can be formed of this polyurethane material, especially in case it is a lightstable material, but the front surface can also be formed of a paint layer. In the present specification, such a paint layer is not considered as being a part of the flexible skin layer. It can be applied on the flexible skin layer by applying it as a so-called in-mould paint on the first mould surface or it can be applied onto the flexible skin layer after having demoulded the trim part. An additional paint layer does not only enable the use of non-lightstable

skin materials but it also enables the production of skin layers with a lower density. The skin layer 1 has preferably an average thickness of between 0.1 and 3 mm, more preferably of between 0.2 and 2 mm. The average thickness can be calculated by determining the ratio between the volume of the skin layer and the surface area thereof. The skin layer 1 has preferably a flexural modulus, measured according to ASTM D790, lower than 100 MPa, preferably lower than 75 MPa.

The intermediate layer 3 between the skin layer 1 and the rigid substrate layer 2 may be made of a curable material which is applied between the skin layer and the substrate layer and which simply adheres both layers to one another when it is cured. The intermediate layer is however preferably a foam layer 3 which is situated underneath the skin layer to provide for a soft touch feeling. Although it can be made of a thermoplastic material, it consists preferably of an open-celled, semi-rigid polyurethane foam layer. The foam layer 3 has preferably an average thickness (which can be calculated in the same way as the average thickness of the skin layer) of between 1 and 7 mm, more preferably of between 2 and 6 mm, and most preferably of between 3 and 6 mm.

The rigid substrate layer 2 has preferably a flexural modulus, measured according to DIN EN 310, higher than 100 MPa, preferably higher than 200 MPa and more preferably higher than 300 MPa. It can be made of a thermoplastic synthetic material such as PP, PVC, SMA or ABS or of a thermosetting material such as polyurethane. Alternatively, it can be made of natural fibres embedded in a polyurethane resin. The substrate layer is usually a non-cellular or micro-cellular material although it is also possible to use a rigid foam as substrate layer.

Figures 1a to 1f illustrate a first method for manufacturing the automotive interior trim part. In this method the flexible skin layer 1 is

produced on a first mould surface 4 of a first mould half 5 by spraying a liquid polyurethane reaction mixture thereon by means of a spray gun 6 (Figure 1a). The rigid substrate layer 2 is produced in a similar way by spraying a liquid polyurethane reaction mixture on a second mould surface 7 of a second mould half 8 by means of a spray gun 9 (Figure 1b).

Suitable, lightstable reaction mixtures for spraying the skin layer 1 are disclosed in EP-B-0 379 246. Non-lightstable, aromatic polyurethane reaction mixtures can also be used when an in-mold coating, in particular a water-based or solvent-based paint coating is first applied onto the first mould surface 4. Instead of applying the paint layer as an in-mold coating, the moulded part can also be post-painted. For spraying the rigid carrier, use can be made for example of the "Elastocoat" system of Elastogran described in Example 5 of WO 93/23237 and comprising 100 parts of the polyol component Elastocoat C 6815/65 and 71 parts of the isocyanate component Elastocoat C 6815/65 .

In a next step, illustrated in Figure 1c, a foamable composition for producing the foam layer 3 is poured onto the skin layer 1, by means of a pouring nozzle 10, and the second mould half 8 is positioned on top of the first mould half 5 to close the mould 5, 8. Suitable foamable compositions, in particular polyurethane foam compositions, are disclosed in WO 93/23237. As illustrated in Figure 1d, the foamable composition is allowed to foam in the mould until the mould cavity 11 is entirely filled. When, instead of a foamable composition, a non-foaming curable adhesive material is used, such a material is preferably sprayed over the surface of the skin layer and/or of the substrate layer.

After the different layers have cured sufficiently, the upper mould half 8 is removed (Figure 1e) and the trim part is demoulded (Figure 1f).

The trim part illustrated in Figure 1f has no undercuts so that it can easily be demoulded. In case of a trim part which has undercuts, the first and/or the second mould half may comprise slides or may be composed of slides to enable the trim part to be demoulded. In order to avoid visible seams on the front side of the sprayed skin layer, a flexible liner can be used as disclosed in WO 02/26461.

Instead of producing the skin layer on the first mould surface 4 by means of a spray technique, it can also be produced on this surface by means of a reaction injection moulding (RIM) technique. As illustrated in Figure 2 a further second mould half 12 is provided which has a further second mould surface 47 and which can be positioned onto the first mould half 5 to define a closed mould cavity 13 having a shape corresponding to the shape of the skin layer 1. The further second mould half 12 is provided with an injection gate 14 through which the reaction mixture for producing the skin layer can be injected. Suitable polyurethane reaction mixtures are disclosed for example in WO 98/14492.

The flexible skin layer 1 can also be made of a thermoplastic material. In the first aspect of the invention it is also made by a low pressure forming process, namely by a slush moulding process, in particular according to a liquid or a powder slush process, by a thermoforming process or by a spray process.

Likewise the rigid substrate layer can be produced on the second mould surface 7 by means of a reaction injection moulding (RIM) technique. As illustrated in Figure 3 a further first mould half 15 is provided which has a further first mould surface 46 and which can be placed onto the second mould half 8 to define a closed mould cavity 16

having a shape corresponding to the shape of the substrate layer 2. The second mould half 8 is now provided with an injection gate 17 through which the reaction mixture for producing the rigid substrate layer 2 can be injected.

When the rigid substrate layer is made of a thermoplastic material, the rigid substrate layer can be made by a liquid or powder slush moulding technique. In the case of a powder slush moulding technique, the thermoplastic material is applied in a powdery state onto the heated second mould surface and is molten thereon. A thermoplastic rigid substrate layer can also be made by a thermoforming process wherein a sheet of a thermoplastic material is formed against the second mould surface by applying heat and some pressure (for example by drawing the sheet by means of a vacuum against the heated second mould surface). A powdery thermoplastic material can also be sprayed onto the second mould surface and molten by heating when being projected onto the second mould surface and/or when arriving onto a heated second mould surface.

In order to achieve by the above-described processes a three-dimensionally shaped laminate as trim part, the first and the second mould surface 4 and 7 each have a predetermined three-dimensional shape which preferably generally correspond to one another. This means that when the first mould surface 4 is generally concave, the second mould surface 7 is generally convex filling (in the closed mould position) preferably at least 10%, more preferably at least 25% of the volume of the cavity 61 formed by the first mould surface 4 and vice versa when the second mould surface 7 is generally concave, the first mould surface 4 is generally convex filling preferably at least 10%, more preferably at least 25% of the volume of the cavity formed by the second mould surface. In case only some portions of the first mould surface are generally concave the corresponding portions of the second

mould surface should be convex filling preferably at least 10%, more preferably at least 25% of the total volume of the cavities formed by the first mould surface and vice versa. Figures 17 and 18 illustrate a general way wherein the volume of the cavity 61 formed by the concave mould surface 4 is to be determined. The total volume of the cavity is first of all divided in cross-sectional slices (having a width of for example 1 cm). The cross-sectional slices are taken in a direction wherein the sum of the volumes of these cross-sectional slices is the largest. The volume of the cross-sectional slices is measured underneath one or more straight lines 62 connecting the tops 63 of the cross-sectional slice. In Figure 17 only one straight line has to be drawn whilst in Figure 18 more straight lines have to be drawn since the mould surface forms higher tops 63 between its edges. When the edge of the mould surface is in a flat plane extending entirely above the mould surface, it does not matter in which direction the cross-sectional slices are taken and the volume of the cavity is the volume determined between this flat plane and the mould surface. On the other hand, when the mould surface is for example generally gutter-shaped, the cross-sectional slices are to be taken in a direction perpendicular to the longitudinal direction of the gutter-shaped mould surface.

Figures 12 to 16 are cross-sectional views of different shapes of trim parts which can be produced and which all are to be considered as a laminate of a skin layer 1, a substrate layer 2 and an intermediate foam layer 3. In Figure 12 it can be seen that the front side of the substrate layer 2 does not have to be entirely parallel to the back side of the skin layer 1 so that the intermediate foam layer 3 has no uniform thickness. Also the substrate layer 2 does not have to have a uniform thickness but may show for example a thicker zone 64. As illustrated in Figure 13, the substrate layer may have also a thinner zone 65. In Figure 13 the substrate layer 2 is pressed at the edges of the

mould against the skin layer 1 whilst in Figure 12 a gap is maintained between the substrate layer 2 and the skin layer 1 so that a vent is provided along the edge of the mould for the foaming reaction mixture. Figure 14 illustrates an embodiment wherein a vent is provided on only one edge of the mould and wherein the first mould surface forms a much shallower cavity. Figure 15 illustrates a cross-section through an instrument panel wherein an insert 66 is placed in the backfoaming mould to reinforce the projecting portion of the instrument panel. The backfoaming mould is moreover provided with vent holes 67. Figure 16 is similar to Figure 15 but illustrates a skin layer 1 and a substrate layer 2 with undercuts 68, 69. Moreover, the substrate layer 2 has again a thicker zone 64 and projects into the projecting portion of the instrument panel so that no separate insert has to be provided for reinforcing this projecting portion.The processes described hereabove for producing the skin layer and the substrate layer, namely spray, RIM, slush and thrermoforming process, are low pressure forming processes. These processes have the advantage that lower pressures are exerted on the mould surface against which said layer is produced. The average pressure exerted onto the mould surface is in particular lower than 20 bar, preferably lower than 10 bar and more preferably lower than 5 bar.

Moreover, the spray, thermoforming and slush processes may be preferable to produce the skin layer and the substrate layer, in view of the fact that the back surface of the achieved skin layer and the front side of achieved substrate layer will not be contaminated (in particular with release agents) so that there will be no deteriorating effect on the adherence to the intermediate layer.

When making the rigid substrate layer 2 starting from a polyurethane reaction mixture, either by a spray or a RIM process, a reinforcement material is preferably embedded in the polyurethane material to increase the flexural modulus and to improve other

characteristics of the substrate layer. By means of glass fibres and/or glass fibre mats, the flexural modulus of a polyurethane substrate layer can for example be increased to a value higher than 600 MPa (measured according to DIN EN 310) whilst without a reinforcement, the flexural modulus of a polyurethane substrate layer is usually lower than 400 MPa.

The reinforced substrate layer can for example be made in accordance with an S-RIM (Structural RIM, insertion of glass fibre mat), an R-RIM (Reinforced RIM, glass or other fibres admixed into the polyurethane reaction mixture), an LFI (Long Fibre Injection) or a similar process. The reinforcement may consist for example of loose fibres, in particular of glass, metal or other fibres, of a woven or non-woven fibre mat, in particular of a glass fibre mat, of metal wires, of metal sheets or of a combination thereof.

In view of the importance of the weight of interior trim parts of automotive vehicles, the total weight of polyurethane substrate layer and reinforcement materials should preferably not be higher than the weight of the corresponding rigid substrate layers made of the known thermoplastic materials. The specific weight of rigid polyurethane is usually lower than that of the thermoplastic materials but the polyurethane substrate layers have to be thicker and/or have to be reinforced to achieve the required flexural modulus. An important advantage of the use of a liquid polyurethane reaction mixture for making the rigid substrate layer is that it enables to apply the reinforcement material or materials only locally or to vary the amounts thereof. It is for example possible to combine an S-RIM process, wherein a glass fibre mat is only applied in one or more predetermined areas, with an R-RIM process wherein reinforcement fibres are distributed over the entire rigid substrate layer. When spraying the reaction mixture, it is possible to blow at the same time fibres in the sprayed reaction mixture. The addition of fibres can be discontinued or reduced in areas where less reinforcement

material is needed. In order to avoid deformations of the trim part as a result of large changes, it is for example sufficient to apply the reinforcement material or one of the reinforcement materials in narrow strips. In areas where the trim part is to be fixed to the car body, in particular by means of clips, the rigid substrate layer can also be reinforced.

Figure 10 illustrates a first embodiment of a door panel wherein, in a peripheral edge zone 48 and in a central connecting zone 49, glass fibre mats are applied to reinforce the door panel whereas in the remaining zones 45 no reinforcement material is provided. The peripheral edge zone 48 is preferably reinforced in view of the fact that the clips 50 are usually situated therein whilst the central connecting zone 49 is preferably reinforced in view of the fact that it contains the door grip 51. Figure 11 illustrates a variant embodiment of a door panel wherein the peripheral edge zone 48 and the central connecting zone 49 are reinforced by means of a metal wire 52. At the location of the clips, the metal wire 52 is preferably provided with loops 53.

Preferably, the zones or areas which are reinforced more than the other zones or areas, in particular by means of fibres, mats or sheets, cover at the most 90%, more preferably at the most 60% and most preferably at the most 30% of the total surface area of the rigid substrate layer. Preferably, the reinforced areas cover at least 2%, more preferably at least 4%, of the total surface area of the rigid substrate layer. It was found that in this way, the total weight of a rigid substrate layer made of a polyurethane reaction mixture could be kept lower than the weight of a corresponding thermoplastic substrate layer whilst still meeting the required mechanical properties. A same result can be achieved by embedding one or more wires in the substrate layer.

A further advantage of the use of a liquid polyurethane reaction mixture for making the rigid substrate layer is that it enables to

integrate or embed electrical and/or mechanical components in the flowable substrate material when producing the rigid substrate layer. In Figure 1b an electrical component 18 is positioned in a recess of the second mould surface 7 and is shielded off by means of a mask 19 when spraying the substrate material. In this way, the electrical component is embedded in the substrate material in such a manner that the strength of the rigid substrate layer is not or less affected than in the prior art methods wherein holes are milled or die cut in the substrate layer to mount electrical and/or mechanical components in the trim part.

The electrical component 18 illustrated in Figures 1b-1f comprises two electrical connector parts, namely an electrical connector part 54, containing two contact pins, on the back side of the substrate layer and an electrical connector part 55, containing also two contact pins, on the front side of the substrate layer.

As disclosed in WO 02/09977 electrical and/or mechanical components can also be integrated in the skin layer. As can be seen in Figure 1a, the electrical component 56 integrated in the skin layer 1 is preferably positioned between upstanding edges 57 on the first mould surface 4 so that the component can easily be positioned and so that an aesthetic transition is formed between the visible skin surface and the electrical component 56. The component is shielded off by means of a mask 58 so that the skin material is only sprayed onto the lateral sides of the electrical component 56.

In order to electrically connect the electrical component 56, it comprises at its back side an electrical connector part provided with two contact holes 59. These holes 59 are arranged to cooperate with the electrical connector pins 55 on the front side of the component 18 which is embedded in the substrate layer to make an electrical connection, both components 18 and 56 being embedded in such a location that, when closing the mould, the pins 55 are inserted in the holes 59. The electrical

connector part 54 on the back side of the component 18 embedded in the rigid substrate layer is arranged to make an electrical connection when mounting the trim part to the car body or to a further rigid substrate layer arranged to be fixed to the car body. This further rigid substrate layer or the car body itself may carry different electrical components such as an electric motor for opening the windows so that the trim part is automatically electrically connected to the electrical components mounted on the car body or on the further rigid substrate layer. Of course, the car body or the further rigid substrate layer have then to be provided with a corresponding electrical connector part.

In the method illustrated in Figures 1a to 1f a new sealing concept is used to seal the mould cavity 11 during formation of the intermediate foam layer 3. As shown on a larger scale in Figure 4, the lower mould half 8 is provided along the edge of the mould cavity 11 with an upstanding edge 20 which has, in contrast to the known cutting edges, a top surface 21 enabling to spray a layer of the flowable skin material of at least 0.3 mm on this top surface 21. The top surface 21 is more particularly substantially flat and has a width of at least 1 mm, preferably of at least 2 mm or it is convex and has an overall curvature radius larger than or equal to 2 mm. The width of the top surface 21 is preferably smaller than 5 mm and comprises for example 2 to 3 mm. Optionally, the top surface 21 may show a surface relief such as undulations or grooves provided a sufficiently thick layer of skin material can be sprayed thereon. Due to the resilient nature of the flexible skin material, an effective seal can be obtained between the skin material and the substrate material, even when the dimensions of the mould halves and the thickness of the rigid substrate layer vary within particular tolerances. More generally, to achieve the new sealing concept, the contact zone 22 between the substrate material and the skin material when the mould 5, 8 is closed should have a width smaller than 10mm,

preferably smaller than 5 mm and more preferably smaller than 3 mm so that a relatively large local pressure is exerted when closing to mould enabling to compress the skin material. Moreover, in the contact zone, the skin material should have a thickness of at least 0.3 mm and preferably of at least 0.4 mm. In order to improve the sealing, a thicker layer of skin material could be applied in the contact zone 22 than in the remaining zone of the skin layer. The above described sealing concept is preferably applied over the entire contact zone but it can also be applied over only a part of the length of the contact zone, preferably over at least 50%, more preferably over at least 70% and most preferable over at least 90% of this length.

When the skin layer and/or the substrate layer are made starting from a flowable and/or molten material, the mould 5, 8 is preferably closed when the skin and/or the substrate material is not completely hardened. In this way not only the skin layer but also the substrate material can be compressed. Moreover, an effective adhesion between the skin layer and the substrate layer can be achieved at the (internal or external) boundaries of the trim part.

In Figure 5 an alternative embodiment is illustrated wherein the skin layer is made in a closed mould cavity, in particular by a RIM process. In contrast to a spray process, the skin layer can be given a sharp top and no upstanding edge is needed on the first mould surface. Instead of providing an upstanding edge on the surface of the first mould half, the skin layer is moulded in such a manner that it shows a ridge 60 having a height sufficient to contact the substrate layer. The use of an upstanding edge is however advantageous in view of the fact that a thinner skin layer can be applied which is cured more quickly. Consequently, even in the contact zone 22 the skin layer preferably has a thickness smaller than 3 mm.

In Figure 6 a variant embodiment is illustrated wherein the substrate material is sprayed against a second mould surface 7 provided with an upstanding edge 23 having a flat top surface 24 whilst in Figure 7 another embodiment is illustrated wherein the substrate material is moulded in a closed mould cavity to form a substrate ridge 61 having a height sufficient to contact the skin layer. Of course, the upstanding edges 20 or ridges 60 for the skin layer can be combined with the upstanding edges 23 or ridges 61 for the substrate layer so that the heights thereof can be reduced.

The sealing concept described hereabove can also be used when manufacturing the flexible skin layer starting from a thermoplastic foil which is thermoformed onto the first mould surface 4, when making the skin by a slush moulding process or when a pre-manufactured skin layer is positioned onto this first mould surface.

In order to increase the flexibility of the skin layer in the zone of contact with the rigid substrate layer, the first mould cavity can be heated to a higher temperature in the area of the contact zone than in the other area or areas. This is especially effective in the case of a thermoplastic skin layer since this skin layer can be weakened by heating the mould surface.

The sealing concept can moreover also be used when forming the substrate layer by a thermoforming process, by a slush moulding process or even by an injection moulding process. It can even be used when a premanufactured substrate layer is positioned onto the second mould surface.

The above described methods for manufacturing a synthetic trim part can be carried out in a continuous line. Figure 8 illustrates a first possible embodiment of a production line wherein both the skin layer and the substrate layer are produced by means of a spray process and wherein the first mould half for producing the skin layer is

passed through a first circuit of workstations and the second mould half for producing the rigid substrate layer through a second circuit of successive workstations. Both the first and the second circuits form a closed loop followed by a number (preferably larger than 2) of first and respectively second mould halves.

The first circuit comprises first of all a workstation 25 for exchanging a first mould half 5 by another first mould half, which may be of a different type or version. In the next workstation 26 the first mould half is cleaned and prepared. Subsequently, an external release agent is sprayed in workstation 27 onto the first mould surface. Then different inserts, such as glass fibre mats, injection moulded elements, electric components etc. can be positioned in workstation 28 onto the first mould surface. In the next three workstations 29-31, the polyurethane reaction mixture for the skin layer is sprayed. Due to the fact that spraying the skin material requires a relatively large amount of time, the spray booths or stations 29-31 are arranged in parallel to increase the spray capacity.

When the first mould halves pass the workstations 25 to 31 the second mould halves pass similar workstations for producing the rigid substrate layer by means of a spray process, namely workstation 32 for exchanging the second mould halves, workstation 33 for spraying the external release agent and two spray stations 34 and 35 which are also arranged in parallel.

When the substrate layer and the skin layer are sprayed, the first and second mould halves 5 and 8 are fixed in a first common workstation 36 onto a mould carrier which enables to open and close the mould. In a next workstation 37 the foamable material is poured onto the skin layer and the mould is closed. In the next two workstations 38 and 39 the foam and skin and substrate materials are allowed to cure. In workstation 40 the mould is opened and the first and second mould halves are removed from the mould carrier. The second mould halves

are then cleaned in workstation 41 whilst the trim parts on the first mould halves are allowed to cure further in workstation 42 before being demoulded in workstation 43. The mould carrier is returned to workstation 36. This can be done via a separate transfer line or via the transfer line for the first or second mould halves.

An advantage of using such separate transfer lines for the first and second mould halves is that less mould carriers are needed and that smaller weights have to be transported and positioned in the different workstations. Moreover, spraying of the skin layer is not hampered by the spraying of the substrate layer.

An important advantage is further that the production of the rigid substrate layer usually takes less time than the production of the flexible skin layer so that a smaller number of second mould halves are needed. This is especially the case when the substrate layers are thermoformed or when use is made of pre-manufactured rigid substrate layers which only have to positioned onto the second mould half. Figure 9 illustrates such a production line. The workstations for producing the skin layer and the foam layer are identical as in Figure 8. However, only one workstation 44 is required to apply the rigid substrate layer on the second mould half. Figure 9 also illustrates a battery of six second mould halves 8 which are all of a different type or version. Since the foaming of the foam layer takes only a few minutes whilst the production of the spray skin layer takes twenty to twenty five minutes, the six different second mould halves are sufficient when the skin layer is continuously produced by means of fifteen to twenty five first mould halves 5.